ELECTRICAL SECTION.

(Stated meeting held Thursday, November 5, 1908.)

Electricity in Refrigeration.

By R. Louis Lloyd.

It is probably not necessary for me to discourse here on the reasons why ice, or its counterpart, artificial cold, are of such importance in the commercial world to-day: how by segregation and civilization mankind has desires and necessities which rise above the immediate provisions of nature, desires which can be satisfied only by the supply of articles inherently poorly adapted existence if natural conditions only prevail.

Artificial warmth, artificial light, artificial power, artificial cold are necessities of civilization. And as necessity is the mother of invention, our engineers have supplied the refrigerating machine. The constantly increasing contamination of our water courses and other bodies of water where ice was harvested, has been a potent factor toward the rapid introduction of machines for ice making. Latter-year improvements have so enhanced the efficiency of the small sizes that the demand has been continually augmented, with the natural result of turning to the electric motor as the most convenient, simple and economical driving power.

The management of our local public electric service company early recognized the enormous possibilities of electric refrigeration and have done much toward popularizing and pushing its use. The results have been very gratifying, and Philadelphia can probably show to-day a larger number of small sizes of refrigerating machines than any city similarly situated. They enter into almost every line of business handling perishable goods, not even omitting the undertaker and the morgue.

I can probably not do better than give you a description of a few of the equipments now in operation in the several lines. We will consider first the outfit of a retail meat shop in the upper part of the city where a "baby" Larsen-Baker compressor is operated by a three H.P. motor. The machine is set up in the basement under the meat box, which is on the floor above. This box is 9′ x 6′ x 11′ high, and holds at times as much as six sides of beef, four or five calves and a dozen lambs, a total of a ton and a half of meat. This is a direct expansion system with a brine tank auxiliary for storage. This tank takes the place of the ice bunker in an ordinary meat box and will hold the temperature down low during the non-operative hours of the machine. With a temperature of 34 degrees when shutting off at night, a rise of only four degrees will be experienced by morning.

In addition to the main box, the counter cases in the store and a corn-beef tank are also refrigerated.

At this time of the year, four hours operation per day is sufficient. In summer about nine hours are necessary, while during January and February the machine is not used at all, unless an unusually hot spell visits us. When ice was used, the yearly bill was $425. The power bill for the first year was $250 and for the second $207. This installation cost less than $1000. Adding interest and depreciation charges at 15% to the power bill makes the total operating cost $360 per year, a saving of 14%. To say nothing of the added advantages of lower temperature, more constantly supplied, dry cold and an improved display counter which increases trade.

In contrast let us turn to a large installation for a combined wholesale and retail meat business. It consists of two 25-ton Vilter refrigerating machines, each driven by a fifty H.P. Northern motor, chain geared; one Triplex plunger brine pump, driven by a 5 H.P. motor; one deep-well pump, driven by a $3\frac{3}{4}$ H.P. motor; one large refrigerator box or cooler 60′ x 17′; three small refrigerator boxes or freezers 20′ x 17′; one pickling room 37′ x 19′ x 11′ high; one brine tank 19′ x 5′ x 8′ deep, situated in the latter room. About 5000 gallons of brine.

The system is brine circulation exclusively, all of the expansion coils being located in the brine tank. Three or four hours' operation of the machine is usually sufficient to reduce the temperature of the brine to five or eight degrees above zero. It is then pumped through pipes in the freezers and the bunker of the cooler during six hours, which keeps these rooms at the proper temperature. After a shut-down of about fifteen or twenty hours this brine has risen to about fifteen degrees.

The object of putting in two refrigerating machines was to permit one machine to rest during the heavy duty in summer and also to allow for growth of the business. The two have never yet been needed both working at the same time. In fact, six hours' work in twenty-four for one machine in the hottest summer weather so far encountered has been found ample. In winter weather one hour's work for the machine and about one and one-half hours' operation for the brine pump is all that is required to produce the desired temperature.

The cooler usually holds about 20,000 pounds of meat, and is maintained at thirty-five degrees. This box is well insulated with layers of cork laid in asphalt pitch. There are three doorways in this box and it is well lighted by incandescent globes.

The wall and counter cases in the store are also cooled by brine pipes located above in the former, and at the bottom of the latter. This permits of the display of choice cuts of meat without fear of deterioration.

The freezer was divided into three rooms in order to accomplish better results and allow considerable elasticity in the accommodations. In certain seasons of the year it is necessary to take care of more of those delicacies which require the very low temperature; and as arranged one, two or three sections can be utilized independently. The temperature can be brought as low as zero in any of these rooms if necessary. Fifteen degrees, however, is found to be ordinarily sufficient.

The pickling room is cold enough at thirty-five degrees, but on account of the presence of the brine tank, the temperature is usually down to thirty degrees without circulation in the coils of this room.

Since the plant was put into operation, in the early spring of 1907, there has not been the slightest delay or trouble from the equipment. It has operated on a 20% load factor and the results have been entirely satisfactory.

The condensing water is obtained from an artesian well, the water being pumped from a sixty-foot depth by a 3¾ H.P. motor, above mentioned.

It is rather difficult to make any comparisan between the cost of operation of this equipment and the cost of ice. Of course the freezers could not have been used and the low temperatures of the other boxes could not have been maintained. Outside storage charges would have been incurred. The heaviest consumption was 4017 K.W. hours for the month of July, and he lightest 1420 K.W. hours in January. The owner of this plant is highly gratified with its operation.

Early in 1907 the Leo. Niessen Co. installed a six-ton machine

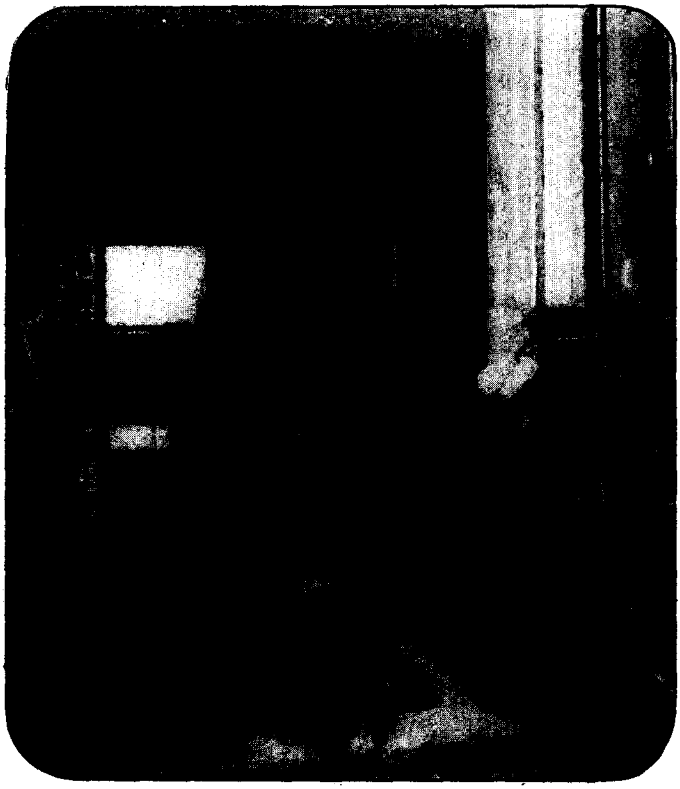

Fig. 1. Six ton refrigeration machine and motor. Silent chain drive.

to take care of their immense stock of flowers in two refrigerators of their new store. See Fig. 1. One box is in the basement and is used for smilax and green stuff. This is 8′x20′ internal dimensions and 8′ high. The desired temperature is thirty-two degrees. The system used is direct expansion with brine tank auxiliary. After fresh crates and boxes have been put away and the temperature has risen ten or fifteen degrees, one hour's operation of the machine will bring the temperature down to thirty-two degrees. The valves feeding this box are then closed, and the work of the machine is all done in the main box in the store. This one is 40′ x 10′ x 12′ high, has two doors and two electric lights. They are burning almost constantly and the doors are open every few minutes throughout the day, which lasts from 7 A.M. to 9 P.M. This box has two brine tanks the length of the box, 3′ deep x 15″ wide. They each contain 300 gallons of brine. All the cooling tubes are in and around these tanks. For the better circulation of the air and to obtain a more uniform temperature, air flues are built on both sides extending to within two feet of the floor. The refrigeration is produced in a sort of a trough which prevents the cold air falling immediately against the flowers on the upper racks. The flues carry it down the sides to be distributed below.

Three to five hours per day the year through is all that this machine is required to operate. It is giving highly satisfactory service and has needed no repairs to date—nearly two years. The bills for power have varied from $43 to $63 per month. This would buy less than half a ton of ice per day. Three times this much ice would not give them equivalent results of cooling. The load factor of the motor for the year is about 40%.

Early last year the proprietors of one of our most prominent retail florist shops decided to adopt mechanical refrigeration.

They had a very handsome display case along the east wall of their establishment, 16½′ long and 9′ high and 42″ wide, embracing about 500 cubic feet. It consisted of a show case with three shelves, drawers below, and an ice bunker above.

These shelves hold jars and vases of cut flowers in water, and they were usually kept full at all times, forty jars holding probably 200 or 300 pounds of water, being the average quantity, and this was renewed daily.

The drawers below contained the smilax and green stuff and were well filled. Openings in the floor and the main case permitted the coldest air to circulate down to and around these goods. Both doors and drawers were opened frequently. There were four of each and the openings would average probably four times per hour each.

Under these conditions it was found necessary to use 500 to 700 pounds of ice each day to maintain a temperature of 54 to 55 degrees.

The annoyance and inconvenience of handling were great. The ice bill for one year was $501. We contended that the cost of power to operate a refrigerating machine to produce equal results would not be over half this amount. A contract was made for a Brunswick refrigerating machine of one ton capacity, which was guaranteed to produce the desired results. The cost of the complete installation in operating condition was a little over $1000. The installation was completed and the machine operating the last week in May, 1907.

In the ice bunker above the case four narrow brine tanks 14′ 9″ long 18″ high and 4″ wide were placed, and the ammonia expansion pipes led into them. Each tank was cooled by 100 feet of one-inch pipe, bent zig-zag and arranged in seven rows each 14′ long. One barrel, or 350 pounds of calcium chloride salt was dissolved in enough water to fill these four tanks, making a weak solution, Sp. Gr. 1.05, with a freezing point just below 26 degrees F. The idea was to freeze this solid and have a result similar to that obtained from ice.

It worked out admirably in practice. At eight in the morning, when the store is opened, the machine is started in operation. The temperature in the cases at this time is found to be just about as it was left the night before, about 45 degrees. They now renew the vases and jars and put in fresh flowers from the hot house. The doors are opened constantly for quite a while, and the temperature rises in the cases sometimes as high as 60 degrees. This will naturally vary at the different seasons of the year, depending upon the temperature of the room, and the water supply. The cases are soon brought down to the desired temperature, and toward evening the tanks will have frozen solid again. The machine is then stopped and remains so over night.

The results have been very satisfactory, and the avoidance of the bother and trouble of handling ice is in itself justification for making the change.

The proprietors have ordered that the machine be overhauled every year, a preventative measure.

This is the way the account stands for the first year:

Cost of electric power	$301.07
Interest, depreciation and repairs	157.00
	$458.07
As compared to ice	501.00
Saving	$43 00

This is numerically not very large, but we must also consider the absence of labor and abuse of this fine case incident to the continual filling of the ice chamber when ice was used. These costs actually existed though not readily shown.

The motor used is a three H.P. Peerless. A test shows it to be taking almost two K.W. as a steady input. It is belted direct to the driving pulley of the machine, which runs at 280 revolutions per minute.

Next is a dairy which handles 4000 quarts of milk per day and requires nine wagons for delivery purposes. The refrigerating machine used is an eight-ton Buffalo plant, driven by a fifteen H.P. motor. The expansion coils are all submerged in a large brine tank situated above the refrigerator box, containing 2000 gallons of calcium chloride brine. Eight or ten hours operation cools this mass to 10 deg. or 20 deg. F. above zero. It is kept in motion by a small pump operating twelve or fifteen hours out of twenty-four, which also circulates it through the cooling coils of the pasteurizer. Two hours are required to pasteurize the 100 cans of milk. This is a continuous process with the improved apparatus and after heating it is rapidly cooled to 40 deg., bottled and set in the refrigerator. This latter is a well insulated room, 26′ x 14′ with 10″ walls. About six feet of the rear end is partitioned off for a sort of a freezer for the better keeping of the cream. This part is cooled as low as 28 deg. The main room ranges from 32 deg. to 40 deg.

The electric power for an entire twelve months for this refrigerating machine was $786, with a K.W. hour consumption of 17403. We notice, however, that the individual months varied greatly, ranging from 2832 in July to none at all in February. The load factor for the year was 50.7%. This is somewhat lower than the average load factor for dairies.

We will now turn our attention to a soda fountain. This, with its counterpart, the saloon installation, is the most difficult yet encountered to properly care for. The requirement of having the beverage served at nearly a freezing temperature and at the same time to constantly avoid its freezing up in the pipes, makes the problem. It is overcome by what is called sweet water circulation. The freezing coils are submerged in a tank of ordinary water of considerable volume. Some ice is allowed to form in this tank, but inasmuch as ice is a non-conductor it acts somewhat as a barrier to further formation after the first coating of a half inch or so. In addition the water is kept in constant circulation during the cooling process. (See Fig. 2.)

The plant in question consists of a three-ton Brunswick refrigerating machine, driven by a $7\frac{1}{2}$ H.P. motor. The water tank is probably 15′x4′x3′ deep and contains all the expansion coils. A small rotary pump, requiring $\frac{1}{4}$ H.P., direct connected to a motor, keeps the water in almost constant circulation from the

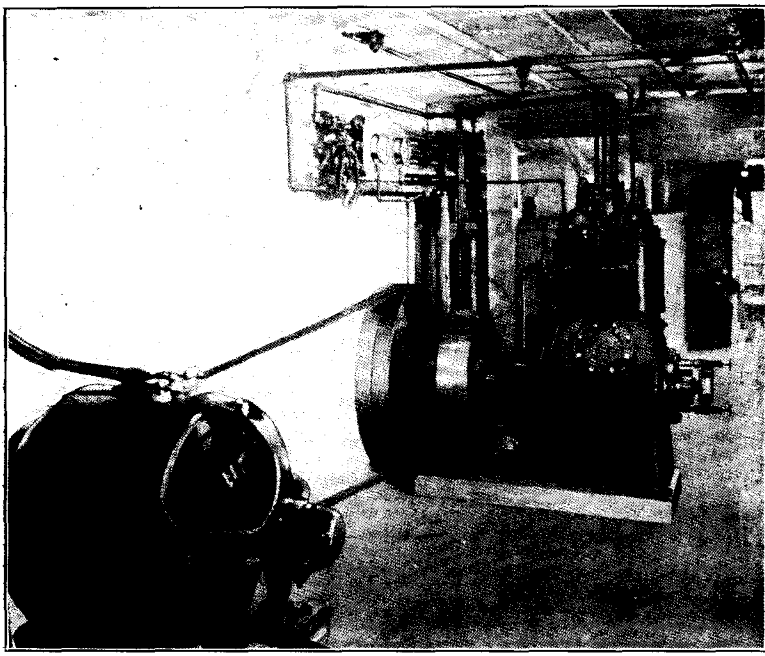

Fig. 2. Three ton refrigerating machine and motor. Belt drive.

tank through three soda fountains and return. The pipe leading from the tank through the pump carries the water at nearly 32 deg. temperature up into the lower compartments of the three fountains in sequence, then up into the coil chamber where it discharges over the soda water pipes, overflowing to the next fountain, and to the last in turn, from which it is returned to the cooling tank.

The operation is found very satisfactory, giving considerably lower temperature to the beverages than was obtained from ice.

The power bill is about one-half the former ice bill, and the confusion, delay and slop of ice deliveries avoided. Total K.W. hours for one year 11428, which is a load factor of 61%. The power used in the hottest month, August, was nearly double that of the cold month, January. The average running time of the compressor was about five hours, while the pump has of late been running continually. It was found that the soda water coils were too long getting chilled in the morning after an all-night rest in the hot store. This loss could no doubt be avoided if a little more attention were given to insulation of soda fountains.

I quote from an article in September, "Ice and Refrigeration," describing a modern bakery at Columbus, Ohio. "At first thought it may seem that refrigeration could have little to do with baking bread, but as a matter of fact it is the refrigerating machine that gives the baker the control over the processes of bread making requisite to the ensuring of the all-important uniformity in product now demanded by the customer."

All the new bakeries use refrigerating machines. Not only the bread bakers, but pie bakers as well. One of the most, if not the most modern and up-to-date establishment of its kind in the world is just about completed and beginning to do business on Tenth Street below Walnut. The Horn & Hardart Baking Company have spent $275,000 in building and equipping this new food-factory to supply the needs of its numerous "Automats" and restaurants, doing strictly a light lunch business. The refrigerating feature is worthy of our attention. (See Fig. 3.) It consists of two eight-ton units, belt-driven from a main shaft so arranged with clutch pulleys that one, or both, or neither can be operated at will. A 40 H.P. motor turns the shaft. The artesian well pump is also connected to the same and operates continuously with either refrigerating machine. Direct expansion, with still brine storage, is used in each of the six refrigerator boxes, the largest of which is the pastry box in the bakery proper. This is 50′ x 10′ x 8′ high, and will hold more pies and things than are consumed by a regiment. The fruit box is just half this size. The meat box is 20′ x 10′. Two small boxes take care of the butter and the immediate supplies for the lunch counters in the building. There are in addition an eight-can ice cream cabinet, an ice storage room and two Tyson Ice-Cream machines. The ice storage room has a capacity of five tons of ice. On one side of this room is erected

Fig. 3. Two eight ton refrigerating machines in parallel.

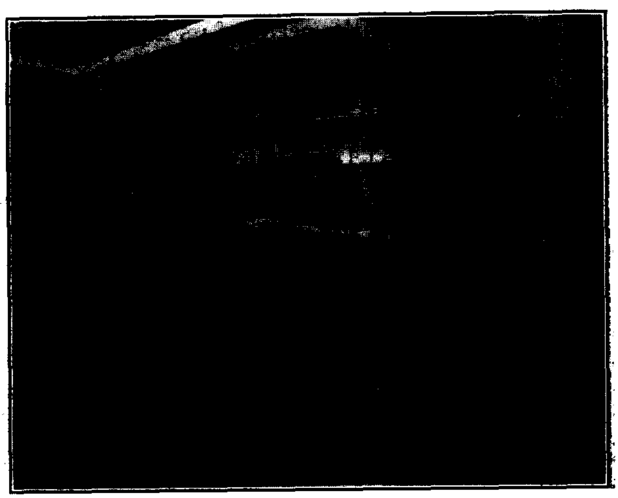

Fig. 4. One-quarter ton refrigerating machine and ice-box.

a double pipe brine cooler, which rapidly chills to zero F. the brine for circulation through the ice cream machines. The temperature of this room is usually about 23 deg.

A restaurant naturally must use some ice. A machine hardly fills the bill for iced tea, lemonade, etc., at least not yet. Several years ago Horn & Hardart became convinced that more of the ice they paid for was lost through melting to waste than was actually used. In each of their restaurants they have installed a small Brunswick machine of quarter ton capacity, to keep their ice from melting. It saves them money. Incidentally it helps cool the food stored in the same box. (See Fig. 4.)

Mr. M. is a confectioner and ice cream maker, enjoying a large retail trade. He uses one ice cream machine, turning out forty quarts at a batch and makes from 200 to 800 quarts per day. The average production during the time covered by this record has been 400 quarts per day, six days a week. The larger portion is sold and served in his parlors, although considerable is sent out on orders. This necessitates the use of some salt and ice. It is a disputed question under such circumstances whether it pays to buy this amount of ice or to put in a plant large enough to make the small quantity which will be required. Leaving occasional unusual conditions out of consideration, it may be stated as a fact that where ice can be purchased for $3.50 or less per ton, there is no economy in making one's own supply. (See Fig. 5.)

The equipment here consists of a two-ton refrigerating machine, belt-driven by a 5 H.P. 2-phase General Electric motor. It is operated nine to fifteen hours per day and cools a large body of brine in a tank 8½′ long 2½′ wide and 3½′ deep sunk in the floor of the basement. Space was at a premium even before the machine was installed, so for the brine tank the cellar floor was excavated and the top of this tank made flush with the floor. The ammonia expansion or coiling pipes are situated in this tank. There is also a brine cooler here, the object of which is to rapidly cool a small portion of the brine just before it is carried out to the ice-cream machine. The brine is circulated from this tank by a No. 5 Gould rotary pump (shown white to the right and below the center of the illustration) to three ice-cream cabinets, two in the basement for storage; one, the serving cabinet, up in the store. Two of these are each 6′ long 2½′ wide and 2½′ deep and hold twelve 40-quart cans of ice cream. The serving cabinet holds twelve cans of different sizes, is well insulated and fitted with a movable top, so that the cans can be lifted out when cleaning is necessary. The third cabinet holds twelve 20-quart cans, making the entire storage capacity equal 950 quarts. These are each on a separate circuit of the brine piping, which branches just beyond the pump. Each line carries a check valve to prevent back flow. The refrigerating machine is operated nine to fifteen hours daily, depending on the weather and amount of ice-cream

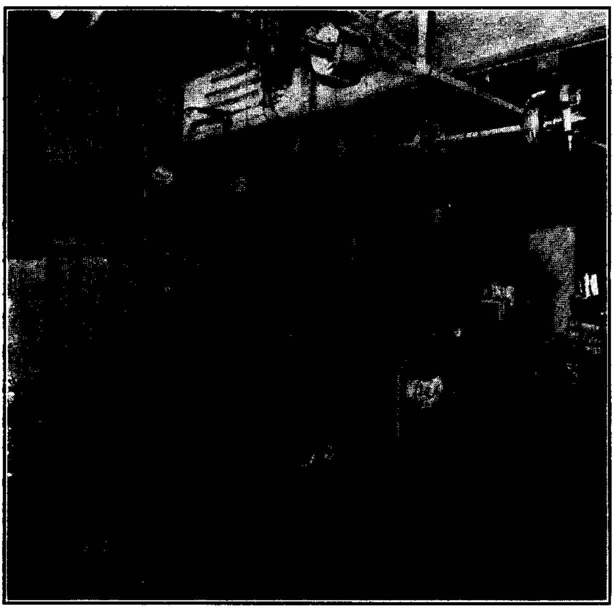

Fig. 5. Two ton refrigerating machine and brine pump. Note cover of the brine-tank in foreground.

made. The brine is kept normally at 4° to 8° F. It is generally brought down to the lower figure at night just before shut down, and in the morning the temperature will have risen to 9° or 10°.

The pipe and cabinets are all well insulated and the heat leakage kept at a minimum. This installation has been in operation during two summers and has proven its worth. Let us glance at some figures.

The cost of operation for three summer months stands as follows:

Ice, 112 tons, at $3.00	$336.00
Salt, 560 bushels, at .35	196.00
Electric power, oil fuses, etc.	227.61
Interest and depreciation	81.25
Repairs	5.00
	$845.86

Compare these with the cost for a similar period before the machine was introduced:

Ice, 208 tons, at $3.00	$624.00
Salt, 1200 bushels, at .35	420.00
Electric power	104.76
Labor, one man, $40	120.00
	$1268.76

Saving in first summer, $422.90.

The item of $5.00 for repairs charged above is inserted to be conservative. As a matter of fact there were no repairs. At the end of the year the machine was overhauled as a matter of precaution, and a charge of $20 incurred. It must not be supposed that the full year will show a saving proportionate to these three months. There are many reasons why it does not, such as labor, change of business from parlor serving to delivery, efficiency of machinery at reduced load, etc. The entire year shows less than twice this figure, but even that is a pretty good investment.

And this is not all. There is probably no business where wet floors and general dampness are more unavoidable or more unhealthy than this, where salt and low temperature must be used. Artificial refrigeration does away with it. This alone should promote its adoption, and when the new dry insulated ice cream carriers become more widely known and used, the ice-cream man will have reached his ideal.

It is our opinion that the near future will show a rapid development in the use of refrigeration equipment for apartment houses and for drinking water systems in office buildings, schools, and public institutions of all kinds. Installations of this character have been used and have proven their value. An apartment house in Chicago has, for ten years, been furnishing ice and refrigeration service from one large centralized plant to ice boxes in each of its one hundred apartments, with very satisfactory results. Flat houses in our city now in contemplation include similar equipment in their plans.

Individual machines suitable for apartments or large residences are in the market and make a very neat and compact arrangement, which allows us to ignore the ice man and his troubles. An electric motor of one horse power size is all that is

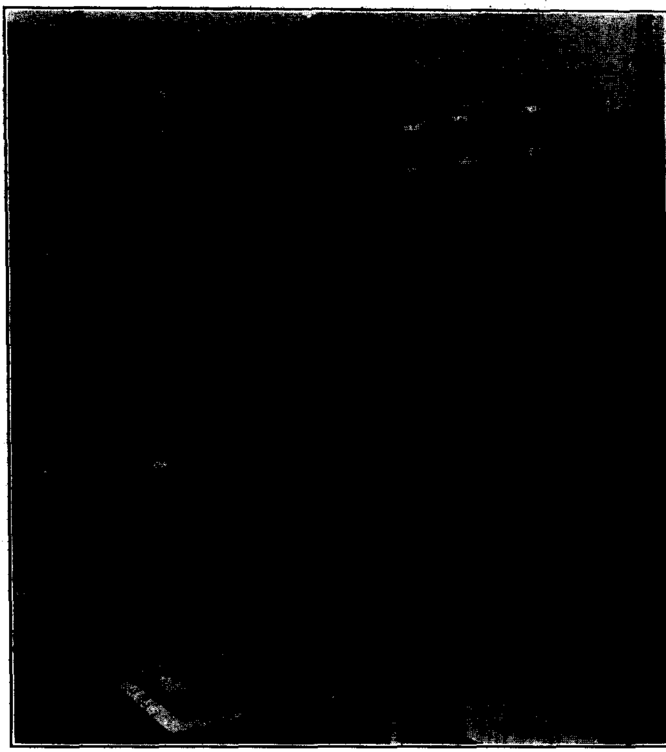

Fig. 6. Small Larsen-Baker machine for cooling drinking water. Pump at the right circulates the water through the building. Each has its individual motor.

needed. The machine is rated as one-quarter ton or one-eighth ton, and will make a small cake of ice for table use as well as keep the box cold. (See Fig. 7.)

Many office buildings are equippe with a cold drinking water system which saves a great amount of running up and down carrying ice every morning. (See Fig. 6.) This illustration shows the machine in the building of the Philadelphia Electric Company which performs this service. It is a two-ton Larsen-Baker outfit, and will cool enough water for two or three times the number of people it now supplies. The expansion coils are submerged in a tank of filtered water and cools it to the desired temperature, usually about 40°. Prevalent popular sentiment calls for drinking water freezing cold. This is a great mistake, and nine out of ten people would pronounce 45°

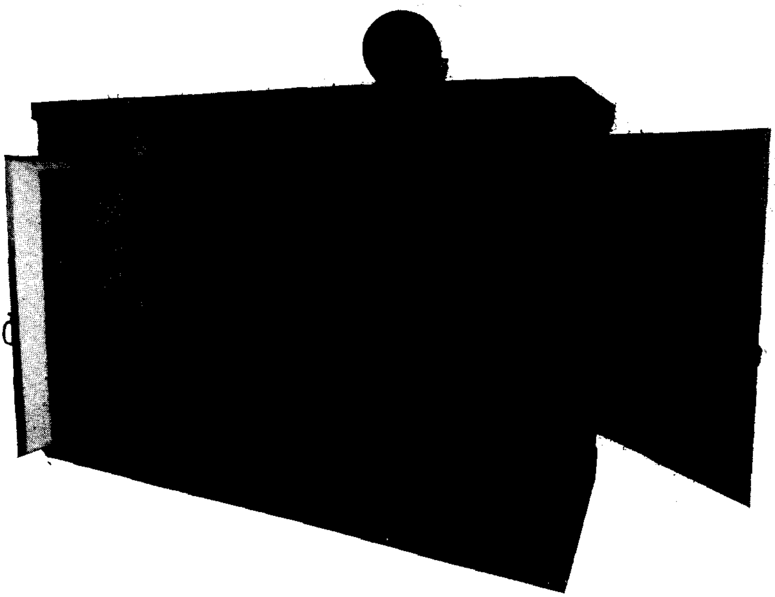

Fig. 7. Brunswick residence type refrigerating outfit and box complete with electric motor.

quite cold enough if unaware of the actual thermometer temperature. From the cooling tank the water is circulated through the building by a small rotary pump, which runs constantly during office hours. The refrigerating machine runs only a few hours out of the twenty-four.

The accompanying table gives figures taken from actual experience and shows the amounts of power used for artificial refrigeration in several lines of business.

	Tons	H.P.	Notes	Kilowatt Hours. Yearly L. E.	Total year	Monthly Ave.	Largest Month.	Smallest Month.	Summer Mon. Ave.	Winter Mon. Ave.	Spring & Fall Ave
Dairy	15	30		48.4%	33351	2779	5293 July	00 Feb.	4801	503	3034
Dairy	3	7	5 H.P. motor on bottle washer included.	56.1%	15463	1288	2294 July	173 Dec.	2069	292	1505
Residence	¼	1		47.5%	1112	93	141 July	42 Feb.	135.6	61.5	83.4
Saloon	3	7½	1 H.P. motor on brine pump included.	62.5%	12438	1036	1383 Sept.	648 Feb.	1288	677	926
Soda Fountain	3	7½	½ H.P. motor on pump included	61 %	11428	952	1318 Aug.	713 Jan.	1050	842	964
Hotel	4	10	1 H.P. motor on brine pump included.	101 %	25500	2125	2760 Aug.	1663 Feb.	2604	1687	2084
Ice Cream	2	5	7 H.P. motor on pump and ice-cream machine included.	54.5%	15008	1250	2023 Aug.	975 Jan.	1830	1164	126
Meat Dealer	1	3	½ H.P. motor on meat chopper included.	48.3%	3955	329	731 July	1 Feb.	706	56	226
Meat, wholesale	35	50		107.9%	123906	10325	28492 July	0 Feb.	23021	1977	5978
Florist, wholesale	6	12		40 %	11046	920	1419 June	580 Jan.	1190	618	953
Butcher	6	15	2 H.P. motor on meat chopper included.	26 %	9275	773	1755 July	155 Feb.	1604	208	700
Florist	1	3		72.6%	5103	425	505 July	311 Feb.	465	334	381

And now I want to say a few words about insulation. Get good insulation. This is paramount. Insulation on a refrigerator is like your clothing in winter. It is all very well to have an abundance of energy and life in your body, but if it is not suitably covered, "Jack Frost" will in the end prevail. So with cooled compartments, pipes, cabinets and ice chests. Here is your small, comparatively so, be it ever so large, refrigerated space and all around is nature's heat fighting to get in and equalize the temperature. Now, the greater the barrier, the better the insulation, the easier is it to keep out the heat. One might have ever so good a machine and be able to remove the heat from a refrigerator very expediciously, but if more heat is constantly leaking in, the machine will have to operate just that much longer, and *that* is the work which costs the money in artificial refrigeration. That is the *continual* expense while outlay for insulation occurs but *once* and brings big returns when done well.

ACETYLENE RULES MODIFIED BY THE NATIONAL BOARD OF FIRE UNDERWRITERS.

The rules formulated by the National Board of Fire Underwriters for the acetylene industry have hitherto required outside installation of acetylene generators, and while, as a matter of fact, in by far the largest part of the United States this rule has not been insisted upon, in certain limited sections it has been rigidly enforced.

The existence of a rule prohibiting the installation of an acetylene generator in an insured building was a constant menace and handicap to the industry, and its enforcement in some sections and not in others placed insurance companies in the inconsistent position of insuring property in one State under conditions which it would not accept in another. An investigation by the National Board, as to the exact condition of the industry, disclosed the fact that, in those sections where inside installation had been permitted, acetylene was proving itself to be a safer illuminant than those which it replaced.

The National Board of Fire Underwriters, at its Executive Committee meeting on January 30th, 1908, held in New York City, after considering the various favorable reports submitted to it by its various committees, amended the rules covering the installation and use of acetylene generators by striking out such words as prohibited inside installation under all conditions and substituted the following: "Generators, especially in closely built up districts, should preferably be placed outside of insured buildings in generator houses constructed and located in compliance with Rule 9."

It will be seen at once that while the National Board recommends outside installation as being ideal, in place of the absolute prohibition, the rules now mean that in all outlying districts generators may be placed in-